

1 Attorney Docket No. 76589

2  
3 OUTER CASING STRUCTURE AND FABRICATION METHOD FOR  
4 CABLE SECTIONS AND NAVY BUOYANT ANTENNAS  
5

6 STATEMENT OF GOVERNMENT INTEREST

7 The present invention may be made or used on behalf of or  
8 for the Government of the United States of America without the  
9 payment of royalties thereon or therefor.  
10

11 CROSS REFERENCE TO RELATED PATENT APPLICATION

12 This application is related to one co-patent application  
13 (Attorney Docket No. 76306) entitled STRENGTH STRAND CONSTRUCTION  
14 FOR A LONGITUDINAL SECTION OF A CABLE, filed on an even date  
15 herewith. This co-pending application hereby incorporated herein  
16 by reference in their entirety.  
17

18 BACKGROUND OF THE INVENTION

19 (1) Field of the Invention

20 The present invention relates to an improved cable section  
21 assembly including a core structure and a protective outer casing  
22 for marine applications and a method for forming said cable  
23 assembly. The invention is of utility in connection with such  
24 assemblies employ by the U.S. Navy as buoyant antenna sections.  
25 An example of a cable section and antenna component is disclosed  
26 in U.S. Patent 6,426,464, issued 30 July 2002, which is hereby  
27 incorporated by reference in its entirety. An example of a

1 composition of material for the core structure which provides  
2 buoyancy is disclosed in U.S. Patent No. 5,606,329 issued 29  
3 February 1997, also hereby incorporated by reference in its  
4 entirety.

5 (2) Description of the Prior Art

6 Cables have been used for a wide variety of marine purposes.  
7 U.S. Patent No. 3,434,104 to Stapleton et al., for example,  
8 illustrates a hydrophone cable constructed of a plurality of  
9 sections which are so constructed and arranged as to provide  
10 protection to the sensing devices carried thereby. The cable  
11 includes a body of cellular material, such as foamed  
12 polyurethane, provided with cavities in its exterior surface, in  
13 which crystal detectors are recessed. The cable further includes  
14 a waterproof jacket enclosing the cellular material body. A  
15 floatation liquid is contained in a space between the outer  
16 jacket and the body. Further, strain members and electrical  
17 conducting wires are enclosed within the body.

18 U.S. Patent No. 3,480,907 to King illustrates a neutrally  
19 buoyant hydrophone streamer in which solid polymeric material,  
20 having a plurality of discrete air-filled particles distributed  
21 throughout, fills all remaining space within a hollow jacket.

22 U.S. Patent No. 3,744,016 to Davis describes a buoyant  
23 seismic streamer housing cable and its electronics. A syntactic

1 foam is molded about the cable/electronics. An abrasion  
2 resistant sheathing encases the syntactic foam.

3 U.S. Patent No. 3,900,543 to Davis describes yet another  
4 neutrally buoyant seismic hydrophone streamer. The streamer is  
5 constructed by extruding a syntactic foam material comprising an  
6 elastomeric material and gas filled microspheres onto a central  
7 stress member to form an elongated streamer member. The streamer  
8 is then covered with a water and oil resistant, abrasion  
9 resistant covering. It may be provided with exteriorly affixed  
10 hydrophones or hydrophones that can be affixed to the foam core.

11 An outer protective sheath can be extruded or otherwise provided  
12 around the streamer and the hydrophones. Extrusion is effected  
13 utilizing a suitable elastoplastic material which can be extruded  
14 at pressures below about 300 psi.

15 U.S. Patent No. 4,733,379 to Lapetina et al. illustrates a  
16 flexible line array assembly which includes an array of spaced-  
17 apart piezoelectric elements arranged in a line. Electrodes are  
18 disposed on the opposing surface areas of the elements and are  
19 coupled to conductors which carry signals produced by the  
20 piezoelectric elements when the elements are stressed by  
21 acoustical signals. A porous, open-cell material is disposed  
22 about the piezoelectric elements as an encasement to maintain the  
23 elements in place and mechanically isolate the elements. An  
24 outer, water-tight jacket encloses the open cell material and  
25 holds a fill fluid carried within the open-cell material. An  
26 electrically conductive flexible sleeve is placed either about  
27 the open-cell material or about the outer jacket to shield the

1 piezoelectric elements from electromagnetic waves.

2 U.S. Patent No. 4,963,420 to Jarrin et al. describes a  
3 buoyant cable assembly which uses a polyethylene material to  
4 separate tubes or cables and a thermoplastic material as an  
5 external sheath. An extrusion process is used to form the cable.

6 In the late 1980s, a new capability was conceived for a  
7 buoyant cable antenna (BCA) which would extend its frequency  
8 range. A requirement of this new system was that the electronic  
9 circuit boards be distributed throughout a section of the BCA.  
10 Thus, the previously used amplifier chassis could no longer be  
11 used.

12 Current BCAs are made of polyethylene. Because polyethylene  
13 requires high heat in the molding process, it has been dismissed  
14 as a molding material for fear that the electronics would be  
15 damaged by the extreme heat. Thus, a room temperature curing  
16 compound, polyurethane, has been selected as the molding  
17 compound.

18 The potted circuit boards used in the BCAs have to withstand  
19 the flexing that the BCA assembly undergoes while deployed at  
20 sea. To accomplish this, the circuit boards are potted in a  
21 polyurethane that exhibits a high durometer reading. The areas  
22 between the molded circuit boards are then overmolded with a  
23 microballoon filled polyurethane compound to provide buoyancy.

24 After fabricating and testing a few of these BCA assemblies,  
25 it became apparent that the buoyant polyurethane compound was not  
26 durable enough to withstand the deployment process. The compound  
27 could be over-flexed during handling, causing cracks and breaks

1 to occur. When deployed using a standard Navy capstan, the  
2 assembly was easily gouged and its integrity was frequently  
3 compromised. After only a few deployments, the test assemblies  
4 quickly deteriorated to the point where they were torn apart by  
5 the capstan mechanism. In addition, the possibility that the  
6 polyurethane compound would become saturated with water during  
7 testing at pressure and thereby exhibit different mechanical  
8 properties and possibly a decrease in buoyancy, was also of  
9 serious concern.

10 Thus, there remained a need for a rugged cable assembly  
11 which can withstand the rigors of deployment and handling.

12

#### 13 SUMMARY OF THE INVENTION

14 Therefore, it is an object of the present invention to  
15 provide a cable assembly for marine applications having increased  
16 stiffness which reduces the possibility of it being accidentally  
17 overflexed.

18 It is a further object of the present invention to provide a  
19 cable assembly as above having a covering which is resistant to  
20 nicks and cuts.

21 It is still a further object of the present invention to  
22 provide a cable assembly as above which can be used as a buoyant  
23 cable antenna.

1       It is yet a further object of the present invention to  
2 provide an improved method for manufacturing a cable assembly  
3 such as a buoyant cable antenna.

4       The foregoing objects are attained by the cable assembly and  
5 the method of the present invention.

6       A cable assembly in accordance with the present invention  
7 broadly comprises a core structure, such as in a buoyant cable  
8 antenna, surrounded by a covering formed from a flexible, heat  
9 shrinkable tubing. The heat shrinkable tubing covering may be  
10 formed from a polyolefin or fluoropolymer heat shrinkable  
11 material. It has been found that such a covering provides  
12 stiffness to the cable assembly as well as a tough skin which is  
13 needed so that the cable assembly is not damaged during handling  
14 and deployment through a capstan mechanism. The core structure,  
15 in a preferred buoyant cable antenna construction, includes a  
16 flexible conduit for housing electrical wires and/or electrical  
17 components, which conduit has overmolded thereabout an outer  
18 layer of syntactic foam material formed by a polyurethane  
19 material having glass microballoons distributed therein.

20       The method of manufacturing the cable assembly of the  
21 present invention broadly comprises providing a length of heat  
22 shrinkable tubing, inflating or expanding the tubing to its  
23 approximate full diameter, inserting the core structure into the  
24 expanded or inflated tubing, and shrinking the tubing around the  
25 core structure.

1        Other details of the cable assembly and the method of  
2 manufacturing the cable assembly, as well as other objects and  
3 advantages attendant thereto, are set forth in the following  
4 description and the accompanying drawings.

#### 6                    BRIEF DESCRIPTION OF THE DRAWINGS

7        FIG. 1 illustrates a sectional view of a mid-portion of a  
8 linear section of a flexible cable assembly which encompasses  
9 electric wires and in accordance with the present invention; and

10       FIG. 2 is in part a sectional view and in part a  
11 diagrammatic view of an end of a cable section assembly showing a  
12 mechanical grip structure useful in the process of inserting a  
13 core structure into flexible heat shrinkable tubing during the  
14 manufacturing process for applying the outer protective casing to  
15 the assembly.

#### 17                   DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

18       Referring to the drawings, FIG. 1 illustrates a longitudinal  
19 cable section assembly 10 in accordance with the present  
20 invention. The cable section assembly 10 includes a core  
21 structure 12, such as a flexible, positively buoyant cable  
22 antenna interim manufacturing step subassembly produced before  
23 application of a protective casing. In cases of intended use of  
24 the cable section as a buoyant cable section in a marine  
25 environment, an effective material from which to mold outer layer  
26 24 is the thermosetting polymer curable at room temperature  
27 loaded with glass microballons in a range of about 15 percent to

1 about 20 percent by weight of the microballoons, as disclosed in  
2 U.S. Patent 5,606,329 to J. Ramstowski and J. Monahan, entitled  
3 "Buoyant Cable Antenna", which is hereby incorporated herein in  
4 its entirety. The flexible, positively buoyant antenna interim  
5 manufacturing step subassembly forming the core structure 12 may  
6 comprise any suitable construction known in the art, including  
7 constructions incorporating electronic printed wiring board  
8 strips and including constructions in which the exterior of the  
9 core structure is in the form of an arrangement of surface  
10 segments formed from a series of separate molded parts. FIG. 1  
11 illustrates one such buoyant cable antenna structure having a  
12 narrow flexible tubing conduit 20 through which a plurality of  
13 electrical wires 22 pass and an overmolded outer annularly cross-  
14 sectioned outer layer portion 24 of polyurethane material having  
15 glass microballoons or microspheres distributed throughout, or  
16 other form of syntactic foam. The conduit 20 may be formed from  
17 any suitable flexible material. The wires 22 may be used to  
18 connect various electrical elements (not shown) such as circuit  
19 boards used in the antenna. These various electrical elements,  
20 as for example circuit board strips, may be housed in the conduit  
21 20 or may be external to the conduit and/or the cable. For  
22 example, the electrical elements may be encapsulated or molded  
23 into the outer layer portion 24.

24 A covering or casing 14 surrounds the core structure 12.  
25 The purpose of the covering 14 is to provide stiffness to the  
26 cable assembly 10 as well as a tough outer skin for preventing  
27 damage to the core structure 12 so that it is not damaged during



1 handling and deployment through a capstan mechanism such as the  
2 submarine borne AN/BRA-24 mechanism for deploying the buoyant  
3 cable antenna. In a preferred cable construction, the covering  
4 14 is formed by a flexible, thermoplastic heat shrinkable tubing  
5 formed from a polyolefin or fluoropolymer material. It is to be  
6 appreciated that in addition to the described cross-sectional  
7 construction each buoyant cable antenna assembly is in the form  
8 of a linear section of cable. The length of the linear section  
9 is determined by such factors as the length of a practical  
10 clamshell molding apparatus to perform overmolding of the  
11 syntactic foam outer layer portion 24 upon a conduit 20, and/or  
12 the distance over which any electronic components incorporated  
13 into the cable need to be distributed. In one illustrative  
14 embodiment the length of a section was approximately 10 to 12  
15 feet in length with a diameter of 0.65 inches.

16 The cable assembly 10, in a preferred embodiment, further  
17 includes a layer 16 of an adhesive material between the core  
18 structure 12 and the covering 14. It has been found that the  
19 adhesive material layer 16 is particularly helpful in preventing  
20 wrinkling of the covering 14. Further in using thermoplastic  
21 heat shrinkable tubing 14 with a layer of heat activated  
22 thermoplastic adhesive material therebetween, it is preferred  
23 that the wall thickness of tubing 14 be sufficient thickness to  
24 exert enough constrictive forces upon the adhesive layer in the  
25 course of heat shrinking to cause the exterior of section  
26 assembly 10 to be uniformly formed throughout its length. For  
27 the case of cable assemblies having outer diameters in the range

1 between 0.5 and 0.75 inches, such minimum thickness of the tubing  
2 wall for achieving a uniformly formed assembly exterior is about  
3  $1/16^{\text{th}}$  of an inch. In a preferred construction of the cable  
4 assembly of the present invention, the adhesive material used for  
5 the layer 16 comprises a heat activated thermoplastic adhesive in  
6 tape form, such as TTS-250 Hot Melt Tape manufactured by 3M  
7 Company of St. Paul, Minnesota, which adhesive material is  
8 rubbery, but not tacky/sticky at room temperature. When the  
9 cable assembly of the present invention is fabricated, the tape  
10 form of adhesive is preferably hand-wrapped around the outside of  
11 the core structure 12 with a small overlap on each preceding wrap  
12 around the girth of the core structure. When later heated, the  
13 adhesive melts and flows. It resolidifies as it cools.

14 The cable assembly 10 is manufactured by providing a core  
15 structure 12 and wrapping adhesive material around the core  
16 structure to form the adhesive material layer 16. Thereafter, a  
17 desired length of the heat shrinkable tubing, forming the  
18 covering 14, is inflated using compressed air to open the tubing  
19 to approximately its full diameter. The compressed air is  
20 preferably flowed into one end of the length of shrink tubing by  
21 means of a gun-type dispenser (not shown) attached to a rubber  
22 hose (not shown) which is attached to a compressed air  
23 regulator/outlet (not shown). Suitable means (not shown) may be  
24 provided to hold the shrink tubing so that it does not blow off  
25 the end of the dispenser.

26 While the tubing is dilated to its approximate full  
27 diameter, the core structure 12 with the wrapped adhesive

1 material layer 16 is introduced into the heat shrinkable tubing  
2 14 through the dilated opening of the tubing which is opposite to  
3 the end receiving the flow of compressed air (or other gaseous  
4 medium). Referring now to FIG. 2, a cable section assembly  
5 normally has cable-end grip devices 32 affixed at the ends of its  
6 core structure. The function of the devices 32 is to provide  
7 mechanical and transmission line coupling with adjoining cable  
8 sections. By way of a short explanation device 32 include a  
9 cylindrical Chinese finger toy type open-mesh-sleeve shown  
10 diagrammatically as element 32, which is jammed around a  
11 cylindrical grip foundation collar 30 formed about a marginal end  
12 portion of conduit 20. Using device 32 as a structure for the  
13 attachment of a pull string 33, core structure 12 is pulled  
14 through the inflated and dilated tubing 14.

15 The other end of line 33 is threaded through the bore of  
16 tubing 14 with a purchase end linear portion of the line (not  
17 shown) projecting, and accessible to be pulled from the end of  
18 the tubing which receives the flow of compressed air. As air is  
19 flowed through tubing 14 the purchase end of line 33 is pulled to  
20 more core structure into a final position for heat shrinking the  
21 tubing thereonto.

22 After the core structure 12 with the adhesive material layer  
23 16 is in its final inserted position within the heat shrinkable  
24 tubing 14, hot air guns may be used to shrink the tubing 14 down  
25 to the outer dimension of the adhesive material layer 16. During  
26 this shrinking operation, sufficient heat should be applied to  
27 the adhesive material layer 16 to melt the adhesive material and

1 cause it to flow. As a result, an excellent bond between the  
2 core structure 12 and the covering 14 is formed. While the  
3 chemistry of the reaction which provides such an excellent bond  
4 is not fully understood, it is believed that it is due to an  
5 inherent affinity of the surfaces of polyolefin or fluoropolymer  
6 material and surfaces of polymer-based materials to moldingly  
7 bond.

8 The hot air guns used in the method of the present invention  
9 may comprise any standard, commercial "off the shelf" hot air  
10 gun. For example, a Raychem model CV-5300 hot air gun or a  
11 Master-Mite model 10008 heat gun may be used. Some hot air guns  
12 come with a special metal attachment for their nozzles to help  
13 process shrink tubing. The attachment has a curved lip which is  
14 designed to help shrink the tubing uniformly without having to  
15 change the position of the hot air gun or the item around which  
16 the shrink tubing is being shrunk. This attachment speeds up the  
17 shrinking process somewhat, but does not have to be used.

18 One of the advantages to using shrink tubing in the manner  
19 described above is that the core structure, such as the buoyant  
20 cable antenna, may be completely constructed and molded prior to  
21 being encased in a protective coating. It eliminates any need to  
22 cast and inject very viscous microsphere-loaded polyurethane into  
23 a narrow cavity. It also gives the final cable structure a  
24 smooth, homogeneous outer surface with no vulnerable soft areas  
25 to be gouged out by the deployment mechanism.

1 Another advantage to the manufacturing method of the present  
2 invention is that it does not involve the use of any hazardous  
3 materials. Further, the manufacturing method does not produce  
4 any structural property of the cable which would interfere with  
5 the emission or reception of the electromagnetic radiation of  
6 interest to an antenna.

7 While the core structure 12 has been described as being a  
8 buoyant cable antenna, the covering 14 of the present invention  
9 may be used to protect other types of core structures such as a  
10 particulate loaded polymer casting of regular shape to be used in  
11 a marine environment. In fact, the covering 14 of the present  
12 invention can be applied to any object in need of a relatively  
13 thin, flexible, protective and water-tight covering regardless of  
14 the length of the object to be encased.

15 It is apparent that there has been provided in accordance  
16 with the present invention a Protective Sheath For Microballoon  
17 Molded Cables which fully satisfies the means, objects and  
18 advantages set forth hereinbefore. While the invention has been  
19 described in relation to cable core structures whose outer  
20 portions are formed of molded plastic-based materials, it is to  
21 be understood that the disclosed concepts and teachings also have  
22 applicability to buoyancy providing cable core structures using  
23 cellular and foamed materials. Further, it is evident that many  
24 alternatives, modifications, and variations will be apparent to  
25 those skilled in the art in light of the foregoing description.

1 Accordingly, it is intended to embrace all such alternatives,  
2 modifications, and variations as fall within the broad scope of  
3 the appended claims.